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ABSTRACT

Described are science cognitive and activity preferences of a sample of secondary students in Georgetown, Malaysia whose perceptions of instructional practices in science were considered. Three instruments were used to collect data. The analysis considers the mean scores and F-test results for a Science Cognitive Preference Inventory, an Activity Preference Inventory, and a Science Activity Occurrence Checklist. The results are generalized to the remainder of urban Malaysia. (SA)

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SCIENCE COGNITIVE AND ACTIVITY PREFERENCES AND THEIR RELATIONSHIP TO PRESENT PRACTICES IN SCIENCE INSTRUCTION IN SECONDARY SCHOOLS IN PENANG, MALAYSIA.

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Introduction

Improvement, future planning, and organization of science instruction should take into consideration a number of student, teacher, and curriculum variables (1).

This study examines some of these variables in order to provide answers to the following questions:

1. What are student cognitive preferences for learning science?
2. What are student activity preferences for doing science?
3. What are the present classroom practices with respect to science instruction?

Answers to questions 1 and 2 provide information for State Departments of Education, curriculum planners, school administrators, and science teachers, for future planning and designing of student learning experiences that wish to take into account student cognitive and activity preferences. Answers to question 3, together with information about student cognitive and activity preferences, will assist in the identification of present classroom practices.

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This study is based on data collected from 3rd, 4th, and 5th form classrooms in Georgetown, Penang, Malaysia, during June and July, 1976, and describes current student preferences and classroom practices in science in that city. It is one of several studies underway or completed - Australia (2), and Hawaii (3).

Design of the Study

1. The Experimental Sample. The independent variables in this study were Form, Achievement, Sex, and Race. Dependent variables were three instruments measuring, respectively, science cognitive preferences, science activity preferences, and classroom practices in science.

Sampling from the population of some fifteen English-medium Government secondary schools in Georgetown, Penang, was carried out as follows: Four of the top schools (two boys', two girls') provided the majority of Superior and High Average students; three other schools (one boys', two girls'), selected to conform to requirements of geography (proximity to the above) and sex, provided High Average and Average students in numbers sufficient to give an overall sample of approximate equivalence with respect to:

(a) Superior, and High Average plus Average students

(b) Boys and Girls

(c) Boys' classes, and Girls' classes

From within these seven single sex schools, (three boys', four girls'), the total of sixty-five classes chosen contained all those students who were capable of easily understanding the English in the test instruments. Relative achievement assessments (Superior, High Average, Average) for

these classes were supplied by the Department of Education. Each class was homogeneous with respect to achievement level.

Student ages were 14+, 15+, and 16+ for 3rd, 4th, and 5th forms respectively. A total of 2187 students were tested, although all students did not participate in all testing. (See Table 1.)

Insert Table 1 here

2. Assumptions. This study involves the following assumptions:

(a) The measures used are valid indicators of student preference orderings.

The assignment of items to one of the four cognitive areas was determined by eight expert judges, and only items achieving at least 90% agreement were included. (See Appendix.)

(b) The sample is representative of all English-speaking students in Penang (Georgetown) with respect to all relevant variables. (By definition, a relevant variable is one which affects the preference ordering of students.)

It is known that the sample is biased (see Design of the Study - 1. The Experimental Sample) with regard to achievement level, but results show that this variable has little effect on preference orderings (see Summary and Conclusions). Achievement, then, is an irrelevant variable. Furthermore, variables which are highly correlated with achievement level may also be irrelevant, and have, therefore, been ignored. Such variables include intelligence, socio-economic level, and motivation.

3. The Criterion Measures. Additional validity and reliability statements for the following three instruments are included in the Appendix:

Instrument I

Science Cognitive Preference Inventory (SCPI), Author: J. Dekkers and P. Tamir (4). A 30-item cognitive preference test which is designed to assess the relative preferences, towards the following four areas, of students who encounter scientific information on familiar topics: recall of facts (R), principles and explanations (P), critical questioning and demand for more information (Q), and practical application (A). There are no right or wrong answers; the answers merely show student preferences. A sample question from the instrument is as follows:

> "The actual percentage of water vapor in air is called the relative humidity.
>
> a. The maximum amount of water vapor in one cubic meter (1 m^3) of air at 30°C is 30 grams.
>
> b. One hundred percent (100%) is the maximum amount of water vapor that can be in the air.
>
> c. Does the number of people in a room affect the humidity of the air?
>
> d. Some plants do not grow very well in an environment with a humidity of less than 50% and, therefore, are not usually commercially grown in such conditions."

Cognitive preference tests have been utilized in a number of studies (5) and their construct validity has been established by numerous researchers (6 - 10). A recent study (10), that considered the above four cognitive modes, concluded that there is a direct relationship between

student cognitive preferences, that is, mode of learning, and the nature of the biology curriculum. No studies exist that have focused on science at the lower secondary level for the purpose of eliciting the above-mentioned relationships.

A test-retest reliability of the SCPI instrument used Australian grade 8 (13 years) high school students (N = 59; 33 males, 26 females) and gave the following results:

(recall) r = 0.81; (principles) r = 0.65
(questioning) r = 0.84; (application) r = 0.79

Instrument II

Activity Preference in Science (APIS), Author: J. Dekkers et al (4).
A 30-item preference test which is designed to assess the relative preference of students in a problem situation in science. It is designed to exemplify five ways of getting information to solve a problem. These ways are: laboratory (L), field-work (FW), reading (R), discussion (D), and individual projects (P). In addition to the overall preference pattern, separate subscores are available for physical and biological science. There are no right or wrong answers; the answers merely show student preferences.

A sample question from the instrument is as follows:

"Changes in heat cause building materials to expand and contract. Activities available for investigation are:

(a) Do an inspection of a number of steel and concrete constructions such as bridges, and multi-story buildings, to locate expansion loops, gaps, and other kinds of expansion devices.

(b) Heat and cool a number of building materials in the laboratory to find out how much they expand and contract.

(c) Read about the expansion and contraction of different building materials."

A recent study on student preferences for the above activities showed that students have definite activity preferences for doing science (11).

The information provided by this instrument can be used to decide the adequacy of the range of science activities provided by the science program in question. A measure of the present range and extent of these activities is, in part, provided by Instrument III (below).

A test-retest reliability carried out with the same sample as used for Instrument I gave the following results:

(laboratory) τ = 0.85; (discussion) τ = 0.72
(field work) τ = 0.69; (reading) τ = 0.87
(project) τ = 0.62

Instrument III

Science Activity Checklist (SAC), Author: J. Dekkers et al (4).

A 57-item questionnaire designed to assess the extent to which particular student and teacher science activities occur in science instruction. SAC is an extensively modified version of a 48-item agree-disagree questionnaire developed by Kochendorfer (12) and modified by FAST (4) to differentiate between traditional textbook-oriented teaching, and inquiry, laboratory-oriented teaching.* SAC is at present used by the FAST evaluation project.

In this instrument, students respond to items relating to particular student and science teacher activities on a 5-point temporal scale (almost always, most of the time, often, some of the time, very seldom).

* Scientific inquiry is defined as a systematic approach for seeking information, including the use of observation, experimentation, questioning, and the use of literature.

Sample questions from the instrument are as follows:

Category 1 - Laboratory Activities: "We discuss results from experiments after each investigation."

Category 2 - Assessment and Evaluation in Science: "My science teacher tells me about my progress in science."

Category 3 - Non Laboratory Activities: "We have class discussion about kinds of evidence that support our conclusions."

Category 4 - Scientific Inquiry: "Our investigations in science are very similar to investigations done by scientists."

Category 5 - Teacher Activities and Role: "Our teacher asks us questions that help us find answers about things that puzzle us in our laboratory investigations."

Information obtained by this instrument provides immediate feedback as to how students perceive the extent and frequency of occurrence of a number of classroom practices. It thus serves to indicate the degree of agreement between science teaching practices and the objectives of science education.

An overall test-retest reliability carried out with Australian high school students (N = 41; all females) gave an τ = 0.65.

The Penang data supplied overall Cronbach alpha values (Forms 3-5) of 0.84 to 0.89.

Students were tested in their own classroom or in a school hall. Instructions were given in English by their science teachers from a standard format. No more than one instrument was administered in any one day, and the instruments were all administered to the total sample over a period of five weeks.

Analysis and Discussion

Instrument I. Science Cognitive Preference Inventory (SCPI)

(a) Forms. Mean scores and F-test results for the total sample as well as for each Form (3-5) are presented in Table 2.

Insert Table 2 here.

It should be noted that, in the Student Response Sheet, the most preferred cognitive mode is given 1 by the student, the next preferred is given 2, the next preferred 3, and the least preferred 4. Thus, high preferences are indicated by low means.

The preferred cognitive modes for the students tested are ordered as follows. These are based on mean scores, which cannot at present be compared statistically within forms because of the unknown effects of such differences as difficulty levels.

All Forms: Principles = Recall (Most preferred) > Application >> Questioning (Least preferred)

Form 3: Recall (Most preferred) > Principles = Application >> Questioning (Least preferred)

Form 4: Principles (Most preferred) > Recall > Application >> Questioning (Least preferred)

Form 5: Principles (Most preferred) > Recall > Application >> Questioning (Least preferred)

The table shows a substantial difference between the high (Questioning) and low (Recall/Principles) mean scores for each form. That is, there is a strong preference for Recall/Principles and a low preference for Questioning.

Analysis of variance was used to test for significant differences between pairs of means for each cognitive mode across the three forms. Differences are significant across all forms only for Principles. That is, from Form 3 to Form 5 the preference for the use of Principles becomes increasingly favored, presumably showing an increasing desire by students to understand rather than merely to absorb factual information.

Conversely, the cognitive mode of Application has a decreasing appeal from Form 3 to Form 5; this mode, apparently, is not considered important for reasons that may be related to the predominantly agricultural economy. Yet, when the above preferences are presented on a subject basis*, a somewhat different situation is revealed:

Biology

All Forms: Recall (Most preferred) > Principles > Application > Questioning (Least preferred)

Physical Science

Form 3: Application (Most preferred) > Principles > Recall > Questioning (Least preferred)

Forms 4/5: Principles (Most preferred) > Application > Recall > Questioning (Least preferred)

Cognitive preferences are, therefore, to some extent dependent upon specific subject areas. The overall cognitive style pattern for the overall test and for biology is similar. For physical science, however, Application shows a preference shift from 3rd place to 1st/2nd place. Presumably, the usefulness and applicability, in a general, social, and scientific context, of scientific information is considered more

* The number of students taking each subject is not known.

important for the physical sciences than for biology. The order of preference across forms for biology is constant; there is one minor change in order for physical science.

Although Questioning shows a significant increase in mean scores from Form 3 to Form 5, this mode is, in all cases, awarded the lowest preference.

It should be noted that the Science Cognitive Preference Inventory scale is relative rather than absolute. For example, the lowest preference may not necessarily imply a dislike; the student merely may like the others better. Similarly, the highest preference may not mean a real liking.

(b) Achievement. The science cognitive preferences of the three student achievement categories, Superior (S), High Average (HA), and Average (A), were next examined. The breakdown of students by achievement is shown in Table 1.

The order of preference for cognitive modes in the three student achievement categories are all very similar to each other and to the orders shown in Table 2, namely:

Principles (Most preferred) > Recall > Application > Questioning (Least preferred)

Table 3, however, shows that there are significant interactions between the achievement categories in different forms.

Insert Table 3 here.

The differences, usually, were for the following reasons:

(a) The superior group (S) generally has (i) a lesser preference for Recall than the high-average (HA) or average (A) students and ,(ii) a greater preference for Questioning than the other two groups.

(b) The superior group (S) generally, but not as significantly, has a lesser preference for Application than, in particular, the average (A) group.

(c) The largest significant differences reflecting the above trends occur in Form 5.

(c) Sex. The breakdown of students by sex in the Penang sample is shown in Table 1.

Table 4 presents mean scores and F-tests for males and females in all Forms.

Insert Table 4 here.

Overall, there is no significant difference in the order of preference for cognitive areas across forms and between the sexes. With minor differences this order is:

Principles = Recall > Application > Questioning
(Most preferred) (Least preferred)

When all items are considered there are no significant differences between male and female preferences in Forms 3 and 4, but in Form 5 there are significant differences for Recall (preferred more by girls than boys) and for Questioning (preferred more by boys than girls). Other differences between the sexes can be noted for both biology and physical science items.

One interesting point, however, emerges when the extent of the difference between the most preferred and the least preferred cognitive mode is compared for the two sexes. See Table 5.

Table 5. Differences between most preferred and least preferred cognitive modes for males and females.

Sex	Form 3 $\Delta\overline{X}$	Form 4 $\Delta\overline{X}$	Form 5 $\Delta\overline{X}$	All Forms $\Delta\overline{X}$
Male	6.2	7.0	6.7	6.5
Female	5.3	7.8	8.7	7.7

$\Delta\overline{X}$ = difference between mean of most and least preferred mode.

Clearly, the girls show an increasing mean difference between the most preferred and the least preferred cognitive areas from Form 3 to Form 5. That is, by the time Form 5 is reached, the girls have more firmly established cognitive-style likes and dislikes than boys, and this may well be due to earlier maturity.

(d) Race. The racial breakdown for the Penang sample is shown in Table 1. The order of cognitive preference for all items and for all subject areas is the same for each of the three racial groups involved, namely, Chinese, Malays, and Indians. This order is:

Principles (Most preferred) > Recall > Application > Questioning (Least preferred)

An analysis of variance of the mean scores based upon race revealed:

(a) no significant differences between the races with respect to any of the cognitive modes

(b) no significant interactions between races and other variables.

Intercorrelations and Factor Analysis of the Cognitive Preference Scores.

Table 6 presents the results of intercorrelations of the cognitive preference scores.

Insert Table 6 here.

This table shows a high negative correlation between Recall and Questioning. That is, students with a high preference for Recall have a low preference for Questioning.

A number of principal data component analyses with Varimax rotation were performed for the SCPI data. A 3 factor solution was accepted for all data as providing the most meaningful structure. This was based on the criteria that all factors accounted for over 80% of the total variance, and accounted for all factors with eigen values greater than 1.

Table 7 presents the results of factor analysis of the cognitive preference scores.

Insert Table 7 here.

In the analysis for the total test, Factor 1 indicates a high inverse relationship between (R) and (Q) scores which is independent of (A) and (P) scores. This factor corresponds to the "curiosity scale" found in previous studies (9, 10, 13, 14). However, unlike previous studies (A) and (P) emerged as separate factors and may be described as "utilization scales". The total scheme may be interpreted as follows:

Factor 1, the "curiosity scale", indicates that students with a high preference for (R) have a low preference for (Q). This factor is rather independent of (P) and (A) as indicated by rather insignificant loadings contributed by (P) and (A).

Factors 2 and 3 suggest that both (P) and (A) scores are independent of each other. That is, a student's (P) score is not significantly

influenced by a student's (A) score and vice versa. However, in Factor 2, the (P) score is inversely related to the (Q) score and in Factor 3 a similar relationship exists between (A) and (Q) and is further affected by (R).

Further insight into the factor structure of the total test is afforded by an examination of the factor structures of the biology and physical science components of the total test. The factor structure of both are very similar to that of the total test. However, there are some significant differences. Firstly, the variance of Factor 1 for biology is higher than for the total test. The reverse applies for the physical science. This means that the "curiosity scale" for the biology may be found more often than for physical science.

The independent structures for the utilization scales (P) and (A) are present in both biology and physical science.

Factors 2 and 3 for the total test and for biology are very similar. This is to be expected since both have similar variances. However, in contrast, the total factor structure of the physical science is different and more complex in light of the rather equitable distribution of variances across three factors. This reflects stronger interaction as observed by (R) on (A) and (P), and by (Q) on (A). As for biology, (Q) is inversely related to (A) and (P). The higher variance of the "A" utilisation scale in physical science as compared to (A) in biology suggests a greater dominance of "A" in physical science that in biology.

Summary and Conclusions.

Table 8 summarizes the science cognitive preferences of the Penang secondary school sample.

Insert Table 8 here

When all the items are considered together, the preferred cognitive order is:

Principles (Most preferred) > Recall > Application >> Questioning (Least preferred)

and this order is invariant for all variables examined. There is, therefore, some evidence to support the view that ordering is not strongly affected by form, achievement level, sex, or race. Furthermore, no reason can be found to argue that Penang is any different from any other urban environment in Malaysia with respect to these preference orderings. Two aspects of the above findings need explanation:

(1) the invariance of the order.

(2) the position of the cognitive modes within this order.

Both of these can be explained by an environment that overrides and masks any effects contributed by the moderator variables. This environment is believed to be in part educational (the dominant place accorded examinations), and part cultural (the reliance upon authority).

Pupils in Forms 4 and 5 - particularly the latter - are a relatively select group with a demonstrated capacity for passing examinations, and many of them are highly motivated with their sights set on sixth form work and beyond. It is to be expected that these students will be using (although not necessarily agreeing with) cognitive styles in science that pay examination dividends, and that the superior students will be enthusiastic users of successful styles.

The examination papers emphasize Recall and Principles, and this is sufficient reason to prefer these styles. Questioning, on the other hand,

may be interesting but hardly a profitable way to use class time; it is, therefore, consistently least preferred. The shifts in preference from Form 3 to Form 5, as well as preferences associated with achievement levels are all believed to be in response to examination demands. Most students prefer what they are expected to do, and eventually, learn to do what they have to do.

Asian culture reveres the scholar (teacher and text) as the repository of "knowledge", and classroom experience in Penang by one of the authors confirms the relative absence of questioning behavior. Students generally hesitate to question the teacher or text in case this is seen as a challenge to authority, knowledge, or status.

These results can be used to support two different views. One is to see an ordering preference for Recall and Principles as reflecting appropriate preparation for examinations that emphasize these cognitive preference areas. The other view is to see a low preference for Questioning as evidence of instruction that does not emphasize inquiry.

Are other preferences possible? Different orders have already been noted for the analysis by subjects (Biology and Physical Science - see Forms). An even more striking example is reported by one of the authors from Queensland, Australia, where Questioning is most preferred (15). This order, both overall and for separate Forms, is as follows:

Questioning (Most preferred) > Recall > Principles = Application (Least preferred)

One wonders whether, if a different cognitive preference order were felt desirable - for example, one emphasizing Questioning as part of an inquiry-type science curriculum - this could be brought about by changing the examination emphasis and, hence, classroom teaching procedures. However, no comparison with the Penang study is at present possible because of lack of knowledge concerning the relative importance of the cultural and educational variables involved. Further research is needed to assess the effect of these factors.

Instrument II. Activity Preference in Science (APIS).

(a) Forms. Mean scores and F-test results for Forms 3-5 are presented in Table 9.

Insert Table 9 here.

In the Student Response sheet, the most preferred activity is given 1 by the student, the next preferred 2, and the least preferred 3. As with Instrument I, high preferences are indicated by low means. It should be noted that both the Science Cognitive Preference Inventory and the Activity Preference in Science scales are relative rather than absolute. For example, the lowest preference may not necessarily imply a dislike; the student may merely like the others better. Similarly, the highest preference may not mean a real liking.

Based on mean scores, the preferred activity areas are:

Overall: (All items, all forms)	Field (Most preferred)	>	Laboratory	>	Projects = Reading	>> Discussion (Least preferred)
Form 3:	Field (Most preferred)	>	Laboratory	>	Projects > Reading	>> Discussion (Least preferred)
Form 4:	Field (Most preferred)	>	Laboratory	>	Projects > Reading	>> Discussion (Least preferred)
Form 5:	Field (Most preferred)	>	Reading	>	Laboratory > Projects	>> Discussion (Least preferred)

The Table shows a substantial difference between the high (Field) and low (Discussion) mean scores for each form. That is, there is a strong preference for Field and a weak preference for Discussion. These results tend to support the findings from the Science Cognitive Preference Inventory

(see Instrument I) where Questioning rated a consistent "Least preferred".

Analysis of variance was used to test for significant differences between pairs of means for each activity area across the three forms. Significant differences occur only between Forms 3 and 5; this is due to the change in preference for Laboratory and Reading. Why should the Laboratory become a less preferred activity (although not statistically significantly so) and Reading a significantly more preferred activity as the scores are examined in sequence from Forms 3 to 5? Presumably because Reading about science results in examination success while the laboratory does not. A probable contributing factor is that the Lower Certificate of Education examination at the end of the 3rd Form year eliminates many of those who dislike reading; those who remain are made up of a large number of students whose preference for reading - real or forced - must be moderate to high.

Discussion is unequivocably the least preferred activity mode in all instances. This is presumably a cultural attribute as Discussion in Asian classrooms (and also in Questioning - see Instrument I) is liable to be viewed as being synonymous with doubting, challenging, and/or questioning the teacher rather than (as it should be) doubting, challenging and/or questioning data and conclusions.

Table 9 also presents results on a subject basis.* This shows a somewhat different order.

* Number of students taking each subject area not known.

Subjects.

Biology: Forms 3-5.	Projects (Most preferred)	= Reading	> Laboratory	> Field	>	Discussion (Least preferred)
Physical Science: Forms 3-5.	Field (Most preferred)	> Laboratory	> Discussion	>	Projects = Reading (Least preferred)	

There is little similarity between the order for the overall test and for biology except that Discussion is least preferred in both cases. There is much more similarity with the physical science order except that Discussion now occupies a position of moderate rather than least preference. Why biology Projects should be most preferred while physical science Projects are least preferred is not clear. Perhaps almost all the Project work is done in biology. There is also evidence for a significant increase in preference for Reading and for Projects in biology. The higher preference for Reading in biology compared with a lower preference in physical science is, perhaps, self-explanatory.

Activity preferences, therefore, are to some extent dependent upon specific subject areas. An interesting observation is that, on a subject basis, Reading and Projects are always closely associated with one another. Perhaps Penang students consider these two activities together because most individual Projects may well be reading exercises which are then written up.

(b) Achievement. The science activity preferences of the three student achievement categories, Superior (S), High Average (HA), and Average (A), were next examined.

Student preference orderings for activity modes are very similar across achievement levels. The findings - which apply to all forms - may be summarized as follows and compared with orders shown under Forms:

Table 10. Activity preferences for different achievement levels.

	Achievement Level		
	Superior	High Average	Average
Overall (All items, all forms)	F>L>P>R>D Essentially same as overall test*	F = L>P>R>D Same as overall test	F = R>L>P>D Shift in reading
Biology	P = R>L>F>D Same as Biology	P = R>L>F>D Same as Biology	P = R>L>F = D Same as Biology
Physical Science	F>L>D>R = P Shift in P and D.	F>L>D = P>R Shift in D.	F>L>D>R>P Shift in P and D.

Table 11, however, provides F values that reveal significant interactions between the achievement categories in different forms. The differences not only reflect a change in order for preferences in the different activity areas, but also the extent of preference for a particular activity in the different subject areas.

Insert Table 11 here

* Compare order under Forms.

A summary of these results is as follows:

(i) Superior and High Average groups are very similar, but compared with the Average groups, have a greater preference for Laboratory and for Field. For each of these activity areas, a majority of the differences between means are statistically significant.

(ii) To a lesser extent than above, the Superior and High Average groups have a greater preference for Projects than the average groups.

(iii) In Forms 4 and 5, Average groups have a greater preference for Discussion than the Superior and High Average groups, and almost all the differences between means are statistically significant.

(iv) Except for Average Form 3 pupils, there are no significant differences between acheivement groups for Reading.

(c) Sex. Table 12 presents mean scores and F-tests for males and females in all forms.

Insert Table 12 here.

There are no significant differences in the patterns for activity preference areas across forms either for all items or for subjects, for either males or females. With minor differences - chiefly reversal of Projects and Reading - this order is:

Field (Most preferred) > Laboratory > Projects > Reading >> Discussion (Least preferred)

However, while order patterns are all very similar, there are a number of significant differences between males and females. These are as follows:

(i) Discussion is invariably the least preferred activity for both males and females for all items and for both subjects. It becomes significantly least preferred by females in Form 5. This lack of Discussion is presumably a cultural factor. (See Forms)

(ii) Females generally have a greater preference for Reading - a passive activity - than males, and this preference is significant for all Forms (all items, and for Biology and Physical Science) and for Forms 3 and 5. Girls also have a generally greater preference than boys for the Laboratory and for the Field. Activity preferences among girls appear to be more firmly established than they are for boys - a probable concomitant of the earlier maturity of girls.

(iii) More significant differences between the sexes occur in Form 5 than in any other form, and this applies to all items and both subjects. Suggested reasons for this include: a) earlier maturation of girls than boys, and b) different goal orientations for the two sexes.

(iv) Fewer significant differences occur in Form 4 than in any other form. Perhaps Form 4 is felt by students to be the year of greatest school and personal stability.

It will be remembered that significant sex differences were not very evident with the Science Cognitive Preference Inventory (SCPI). The fact that significant differences between the sexes are encountered with the Activity Preference in Science (APIS) suggests that the kinds of activities provided in science programs should perhaps be determined by the sex of the group receiving instruction.

(d) Race. The activity ordering preferences (All items and All Forms) for the several races are as follows:

Chinese: Field (Most preferred) > Laboratory > Projects > Reading >> Discussion (Least preferred)

This order is the same as that found for Forms, Achievement, and Sex.

Malays and Indians:

Field (Most preferred) >> Reading > Laboratory > Projects >> Discussion (Least preferred)

Again this order is essentially the same as previously except for the shift in Reading.

However, an analysis of variance between races in different Forms does reveal some significant differences, particularly in Form 5 and with Biology items. See Table 13.

Insert Table 13 here.

Generally, the results fall into two groups. The Chinese in one group, and the Malays and Indians in the second group.

The Chinese in All Forms have a greater overall preference for Laboratory, Field, and Projects than the other two racial groups. At the same time, the Chinese tend to have less preference for Discussion than the Malays and Indians. These differences tend to account for the significant F-values. Only minor differences occur between the Malays and Indians.

Intercorrelations and Factor Analysis of the Activity Preference Scores.

Table 14 presents the results of intercorrelations of the activity preference scores.

Insert Table 14 here

Table 15 presents the results of factor analysis of the activity preference scores.

Insert Table 15 here

The factors that emerged are as follows:

Factor 1 (Laboratory) - (Reading)
Factor 2 (Discussion) - (Projects)
Factor 3 (Field)

Factors 1 and 2 show relatively strong loadings of opposite sign. Factor 1 indicates a high inverse relationship between (R) and (L) that is affected by (P) scores. Factor 2 reveals an analagous situation to the (D) - (P) pair score that is only slightly affected by the (F) score. (F) emerges as a separate factor. It, however, is inversely related to (R).

The scheme may be interpreted as indicating that students with a high preference for (L) have a lower preference for (R) and vice versa.

Preferences for (L) appear to be closely associated with preferences for (P). Furthermore, a low or high preference for (D) is associated with high or low preferences for (P). Preference for field work (F) is apparently rather independent of the other activities although it is somewhat inversely related to (R).

A similar factor structure emerges for biology, but the structure for physical science is somewhat different. It is as follows:

Factor 1 (Field) - (Reading)
Factor 2 (Projects) - (Discussion)
Factor 3 (Laboratory).

Factors 1 and 2 in physical science bear strong inverse relationships, and Factor 3 contains an independent component.

It is of interest that the factor analysis of the SCPI and APIS data supports the contention that cognitive and activity preferences for science are subject area dependent.

Summary and Conclusions.

Table 16 summarizes the activity preferences in science of the Penang secondary school sample.

Insert Table 16 here.

When all items are considered together the preferred activity ordering is:

Field > Laboratory > Projects > Reading >> Discussion
(Most preferred) (Least preferred)

and this order is essentially the same for all variables concerned. There is, therefore, some evidence to support the view that activity preference orderings are not strongly affected by form, achievement level, sex or race.

Furthermore, there appears no reason to believe that Penang is any different from any other urban environment in Malaysia with respect to these preference orderings. One is tempted to explain the invariant order by suggesting the same reasons as those advanced for the Science Cognitive Preference Inventory, namely, cultural (low preference for Questioning/Discussion), and educational (high preference for activities that produce examination success). Certainly the cultural aspect seems solid enough, yet one wonders whether Field activities are related to examination success. Perhaps they are not, and they are preferred simply because students like to get out of the classroom and do their science outside. In other words, Field appears to be a real preference as distinct from a Teacher/Examination imposed preference. Similarly, the relegation of both Questioning and Discussion to a "Least Preferred" position seems a real preference because both these ways of learning are demonstrably unfamiliar to Malaysians.

For the two instruments (SCPI and APIS) examined to date, areas of low cultural preference tend to be least preferred by students yet, at the same time, these appear to be real preferences; educational preferences, on the other hand, tend to be most preferred and appear to consist of both real and imposed preferences.

Other educational systems produce, apparently, different activity preference orderings. In Australia, for example, a recent study (16) showed that Reading was least preferred, and Discussion was of moderate preference for several 3rd Form classes.

Instrument III. Science Activity Checklist (SAC).

(a) Forms. Mean scores and F-test results for each science activity category for All students and for Forms 3-5 are presented in Table 17 The "I" column or "mean item score" is obtained by dividing the mean category score by the number of items in that category.

Insert Table 17 here.

In the Student Response Sheet students are asked to check (✓) each activity as occurring Almost Always, Most of the Time, Often, Some of the Time, or Very Seldom, and these are coded 1 (Almost Always) to 5 (Very Seldom). The lower the mean the greater the evidence of an inquiry approach to science instruction (see definition of Inquiry, Part I.)

When the item means (I) are ordered for the five activity categories, the following results are obtained:

All Forms: Scientific Inquiry Activities > Evaluation Activities > Laboratory Activities > Class Activities > Teacher Role Activities

Form 3: Class Activities = Evaluation > Scientific Inquiry > Laboratory > Teacher Role

Form 4: Scientific Inquiry > Laboratory > Evaluation > Class Activities > Teacher Role

Form 5: Scientific Inquiry > Laboratory > Evaluation > Class Activities > Teacher Role

(Most traditional; least inquiry oriented)

(Least traditional; most inquiry oriented)

These results - all but one of which are on the high side of the Response Scale mean of 3.0 - reflect a very traditional textbook oriented approach. Scientific Inquiry activities (except for Form 3) are seen as being approached in a somewhat traditional manner; Teacher Role is seen as the least traditional activity.

Three out of five activity categories show a statistically significant increase in mean scores from Form 3 to Form 5, indicating an increase in the traditional textbook-oriented approach as the important Malaysian Certificate of Education examination approaches at the end of the Form 5 year.

(b) Achievement. The perceptions about science instruction held by the different achievement levels were next examined.

Table 18 provides means and F-values that show several significant differences between the achievement levels for All Forms and for Forms 3-5.

Insert Table 18 here.

When the item means (I) are ordered, the following results are obtained:

All Forms:

Superior: Scientific Inquiry > Evaluation > Class Activities > Laboratory > Teacher Role

High Average: Scientific Inquiry > Evaluation > Laboratory > Class Activities > Teacher Role

Average: Laboratory > Scientific Inquiry > Evaluation > Class Activities > Teacher Role

(Most traditional; least inquiry oriented) (Least traditional; most inquiry oriented)

Again, these results reflect a very traditional textbook-oriented approach with Scientific Inquiry activities more conventional than Teacher Role. The reader may wish to order item means for Forms 3-5.

The position of Laboratory Activities in the ordering sequence deserves comment. Superior and High Average achievers perceive Laboratory as being somewhat inquiry-oriented whereas Average achievers (particularly All Forms and Forms 3 and 4) see Laboratory as the most traditional of the five categories.

Such ordering suggests that the brighter students have fairly rigorous laboratory sessions more in tune with those of real scientists; Average achievers, on the other hand, do not seem to operate in the laboratory as do scientists in the real world (see Summary and Conclusions). Presumably teachers feel that Superior and High Average achievers are able to operate within an inquiry mode, whereas average achievers are not. The reason for such decisions could well be connected with the disparate time needed by the several achievement levels to complete the science syllabus when taught as inquiry.

The principal conclusions are as follows:

(i) Laboratory Activities are considered significantly more inquiry-oriented by Superior and High Average achievers (All Forms, and Forms 3-5 - particularly Form 4).

(ii) Teacher Role Activities are seen as significantly more inquiry-oriented by Superior than by Average achievers.

(iii) Evaluation Activities are seen as significantly more inquiry-oriented by Average than by Superior achievers (Forms 3 and 5).

(iv) Scientific Inquiry Activities are seen as significantly more inquiry oriented by Average than by Superior achievers (Forms 3 and 4).

(c) Sex. The perceptions about science instruction held by the two sexes were next examined. Table 19 provides means and F-values for males and females in all forms.

Insert Table 19 here.

An ordering of item means (I) produces the following results:

All Forms:

Males: Scientific Inquiry > Laboratory ≥ Evaluation ≥ Class Activities > Teacher Role

Females: Scientific Inquiry > Evaluation ≥ Laboratory > Class Activities > Teacher Role

(Most traditional; least inquiry oriented) (Least traditional; most inquiry oriented)

Scientific Inquiry is seen as the least inquiry-oriented activity; Teacher Role as the most. The reader may wish to order item means for Forms 3-5.

These data provide the following conclusions:

(i) For every category, for All Forms and for Forms 3-5, males (with one exception in Form 3) have lower mean scores than females. Also, in Forms 3 and 4, and for All Forms, at least four out of the five activity categories have significantly lower means for boys than girls.

(ii) For both sexes, increasing means show a general trend towards a more formal type of science instruction in Form 5.

(iii) At the Form 5 level, significant differences between means apply to only two out of the five activity categories. This indicates again a more similar classroom environment for the sexes than existed in the lower forms.

The above findings are believed to be in response to external examination demands.

(d) Race. The perceptions about science instruction held by the three races were next examined.

Table 20 provides means and F-values for Chinese, Malays, and Indians in All Forms.

Insert Table 20 here.

When the item means (I) are ordered the following results are obtained:

All Forms:

Chinese:	Scientific Inquiry	>	Evaluation	≥	Laboratory	>	Class Activities	> Teacher Role
Malays:	Scientific Inquiry	>	Laboratory	>	Evaluation	>	Class Activities	> Teacher Role
Indians:	Scientific Inquiry	>	Evaluation	≥	Laboratory	>	Class Activities	> Teacher Role

(Most traditional; least inquiry oriented)

(Least traditional; most inquiry oriented)

The overall order is essentially the same as for the previous variables. The reader may wish to order item means for Forms 3-5.

The following conclusions may be drawn:

(i) The higher mean scores for Chinese in almost every case - particularly the number of significant differences at Form 5 - seems to suggest that the Chinese perceive their science instruction as more formal and traditional than the other two races.

(ii) The mean scores of Indians (except for Form 3) are the lowest of the three races and point to their perception of instruction as being the most inquiry oriented of the three races.

(iii) With minor differences, the mean scores of Malays and Indians are very similar to each other indicating fairly close agreement on the kind of instruction they are receiving.

In view of the fact that classes are mixed racially, the authors have difficulty in providing an explanation for (i) and (ii) above.

Summary and Conclusions. Table 21 summarizes student perceptions of science activities during science instruction in the Penang secondary school sample.

Insert Table 21 here.

Entry I (Order) in the Table shows the overall result of ordering the item means for the different categories. Two facts emerge:

1. All categories (with the exception of Class Activities and, in particular, Teacher Role) are seen as either neutral or tending towards a more formal, traditional, textbook approach. Teacher Role is seen as somewhat more inquiry oriented.

2. This order is essentially constant for all variables concerned. That is, there is some evidence to support the view that student perceptions of science activities during science instruction are not affected by form, achievement level, sex, or race. Furthermore, there appears no reason to believe Penang is any different from any other urban environment in Malaysia with respect to these perceptions.

3. While the order of categories is not essentially affected by achievement level, sex, or race, these variables did affect the extent to which classroom activities were either inquiry oriented or traditional - especially for sex.

Why is the Teacher Role more inquiry-oriented than Laboratory when a reasonable assumption appears to be that what happens in the Laboratory is a direct reflection of teacher behavior?

Clues may be found in an examination of Teacher Role which shows that this category subsumes items that involves questioning, class discussion, and telling. In response to these items, students perceive an instructional environment in Penang in which the teacher:

(a) Asks questions that:- relate the present topic to previous learning, help students find answers to laboratory problems, encourage thought about class science activities, and (b) encourages students to:- disagree with him where necessary, record only experimental data actually observed, share ideas and findings with other groups, understand rather than to memorize.

Such classroom activities as these emphasize the inquiry mode of instruction.

The Laboratory, on the other hand, subsumes items that involve experimental procedures as well as discussion and questioning. In spite of the fact that these are all components of inquiry, students perceive an instructional environment in which:

(a) experimental findings are seldom investigated further

(b) students rarely design their own experiments

(c) there is little analysis and discussion of peer results (including unusual data) in order to reach a group consensus

(d) students generally do not use the laboratory to test hypotheses

(e) alternative methods of attacking laboratory problems are seldom considered.

The distinction between teacher verbal behavior and what actually happens in the laboratory is seen in teacher encouragement to "share ideas and findings with other groups" (Teacher Role) yet, in practice, "little analysis and discussion of peer results to reach a group consensus" takes place (Laboratory). In a true inquiry type classroom teacher questioning and laboratory practice are closely integrated.

As with Instruments I and II, the invariant order reflects a uniformity of classroom environment which is believed to be in response to examination demands. It should be noted, however, that the Science Activity Checklist scale (as with scales for Instruments I and II) is relative rather than absolute. For example, the least traditional activity may not necessarily imply a strong inquiry component; the other activities may merely contain less. Similarly, the most traditional activity may not be strongly traditional.

Teacher responses to this Checklist confirm, in general, student responses. Details are as follows:

1. Teacher order for the different categories is the same as that for students.
2. Teacher use of scale extremes is less than that for students.
3. Teacher style becomes more traditional between Forms 3 and 5, and student data confirm this.
4. Significant differences ($p<0.05$) for Evaluation, Class Activities, and Teacher Role occur between Forms 4 and 5.

   An N of 42 limits further analysis.

Questions for Further Research

1. Can these findings, involving English-speaking students, be generalized to students who are poor in English or who do not speak English?
2. Does the trend described under Achievement continue to the below average students? That is, do the latter show a lesser preference for Recall and a greater preference for Questioning?
3. Can the findings of this study be generalized to rural Malaysia?

This paper has described the science cognitive and activity preferences, together with the perceptions of present instructional practices in science, of a sample of Penang, Malaysia, secondary school boys and girls and their science teachers, and has inferred from these findings to the remainder of urban Malaysia.

If change is desired in Malaysian science classrooms - and there is evidence that it is from the recent and continuing support of curriculum development in Science Education - then student preferences and student perceptions of science instruction may well merit attention.

Comments on this paper from teachers and others interested will be welcomed. Communications may be addressed either directly to the authors or to the Editor of this Journal.

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Table 1

STUDENT POPULATIONS ON DIFFERENT FORMS AND TESTS

	TOTAL POPULATION			FORM 3			FORM 4			FORM 5		
	SCPI	APIS	SAC	SCPI	APIS	SAC	SCPI	APIS	SAC	SCPI	APIS	SAC
Total	2187	2164	2172	793	789	785	678	685	692	716	690	695
Sex: Male	1018	1025	1000	374	369	364	317	322	326	327	334	320
Female	1169	1139	1162	419	420	412	361	363	366	389	356	375
Achievement:												
Superior	1075	1055	1069	379	374	369	347	354	360	349	324	340
High Average	342	342	332	146	148	148	104	103	104	92	91	80
Average	770	767	771	286	267	268	227	225	228	275	275	275
Race: Chinese	1476	1491	1464	550	547	542	442	451	454	484	493	468
Malays	542	507	542	173	173	173	189	187	190	180	147	179
Indians	168	166	166	69	69	70	47	47	48	52	50	45

TABLE 2

MEAN SCORES AND F VALUES FOR COGNITIVE MODES IN DIFFERENT FORMS (SCPI).

Cognitive Mode	All students		FORM 3 (a)		FORM 4 (b)		FORM 5 (c)		F Value		
All Items	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	a:b (df=1;1469)	a:c (df=1;1507)	b:c (df=1;1393)
Recall (R)	72.2	10.4	72.4	9.6	72.3	9.9	71.9	11.7	NS	NS	NS
Principles (P)	72.2	6.7	73.4	6.5	71.9	6.5	71.2	6.8	19.0*	43.0*	4.2**
Questioning (Q)	79.3	11.6	78.8	10.8	79.3	11.2	80.0	12.9	NS	3.9**	NS
Application (A)	74.1	6.5	73.4	6.4	74.2	6.5	74.7	6.5	4.9**	14.0*	NS
Biology Items											
Recall (R)	41.6	7.1	41.6	6.6	41.6	7.1	41.6	6.7	NS	NS	NS
Principles (P)	43.9	5.0	44.5	5.0	43.8	4.9	43.3	5.0	8.3*	19.6*	NS
Questioning (Q)	47.3	7.8	47.1	7.2	47.5	7.5	47.4	8.6	NS	NS	NS
Application (A)	45.6	4.8	45.5	4.9	45.6	4.8	45.9	4.8	NS	NS	NS
Phys. Sc. Items											
Recall (R)	30.6	5.1	30.8	4.8	30.7	4.8	30.3	5.7	NS	NS	NS
Principles (P)	28.3	3.9	28.9	3.9	28.1	3.8	27.8	3.9	14.5*	30.7*	NS
Questioning (Q)	32.0	5.3	31.7	5.0	31.8	5.2	32.6	5.7	NS	10.1*	7.6*
Application (A)	28.4	4.1	27.9	4.0	28.6	4.2	28.8	4.0	10.8*	17.4*	NS

Only statistically significant F values are reported * p = .01, ** p = .05 level

TABLE 3

MEANS STANDARD DEVIATION AND F VALUES FOR COGNITIVE MODES FOR ACHIEVEMENT (SCPI)

Cognitive Area	ALL ITEMS Achievement						F Value df= 1; 2184	BIOLOGY ITEMS Achievement						F Value df= 1; 2184	PHYSICAL SCIENCE ITEMS Achievement						F Value df= 1; 2184
	Superior N=1075		High Average N=342		Average N=770			Superior N=1075		High Average N=342		Average N=770			Superior N=1075		High Average N=342		Average N=770		
All Forms	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	
Recall	73.0	10.6	70.2	11.0	72.1	9.8	9.6*	41.8	7.4	41.0	7.0	41.5	6.7	NS	31.2	4.8	29.2	5.7	30.5	5.1	19.7*
Principles	72.2	6.5	72.4	7.1	72.1	6.8	NS	44.1	4.9	43.8	5.3	43.8	4.9	NS	28.2	3.9	28.6	3.6	28.4	4.0	NS
Questioning	78.7	11.8	79.6	11.2	81.1	12.0	5.6*	46.8	8.0	47.6	7.5	48.4	7.8	6.9*	31.9	5.3	32.0	5.4	32.6	5.3	NS
Application	73.9	6.6	73.6	6.4	74.4	6.4	NS	44.8	4.9	45.9	4.8	45.9	4.8	5.4**	28.2	4.0	28.5	4.3	28.9	4.2	4.0**
Form 3																					
Recall	73.7	10.1	71.8	9.6	70.8	8.4	7.6*	41.8	7.0	42.6	6.9	41.4	6.8	NS	31.9	4.7	30.7	4.8	29.4	4.6	22.4*
Principles	73.4	6.3	74.3	7.2	73.0	6.5	NS	44.7	5.0	45.3	5.3	43.8	4.9	5.3**	28.6	4.0	29.0	3.9	29.3	3.9	NS
Questioning	79.4	11.6	78.4	11.9	79.6	8.7	NS	46.6	7.9	46.9	7.6	47.9	5.8	NS	31.8	5.0	31.5	5.7	31.7	4.6	NS
Application	72.8	6.6	72.8	6.4	74.7	6.0	7.5	45.6	4.9	45.0	5.0	45.7	4.7	NS	27.2	3.9	27.8	4.1	29.0	4.0	16.6*
Form 4																					
Recall	72.2	10.1	72.3	8.7	72.3	10.0	NS	41.4	7.3	42.6	6.9	41.4	6.8	NS	30.8	4.7	30.1	4.4	30.9	5.1	NS
Principles	71.8	8.7	71.0	6.0	72.4	7.0	NS	43.7	4.8	43.2	4.7	44.1	5.2	NS	28.1	3.9	27.8	3.4	28.3	4.0	NS
Questioning	79.0	11.5	79.7	6.8	79.7	11.8	NS	47.3	7.7	47.5	6.4	47.8	7.7	NS	31.6	5.2	32.2	4.3	31.8	5.6	NS
Application	74.6	6.5	73.9	6.1	73.6	6.6	NS	45.9	4.8	44.7	4.9	45.5	4.6	NS	28.7	4.1	29.2	4.3	28.2	4.4	NS
Form 5																					
Recall	73.0	11.6	73.0	10.6	65.0	13.4	19.3*	42.2	8.0	41.7	7.2	39.0	7.4	6.4*	30.7	5.1	31.3	7.0	25.9	5.3	34.7*
Principles	71.5	6.7	70.9	7.3	70.8	6.8	NS	43.8	5.0	42.1	5.6	43.3	4.9	NS	27.7	3.8	27.5	4.1	28.8	3.3	3.6**
Questioning	78.6	12.4	70.5	12.9	86.8	13.4	15.6*	46.4	8.2	47.2	8.5	52.0	8.7	16.5*	32.2	5.6	34.8	5.5	35.3	5.2	8.2
Application	74.5	6.5	75.1	6.7	74.7	6.5	NS	45.8	4.9	45.0	4.2	46.4	5.0	NS	28.8	3.9	30.1	4.1	28.3	4.1	7.2*

Only significant F values reported ** p = .05, * p = .01 level.

TABLE 4

MEANS SCORES AND F VALUES OF COGNITIVE PREFERENCES OF MALES AND FEMALES (SCPI)

	ALL FORMS					FORM 3					FORM 4					FORM 5				
	Males		Females		F	Males		Females		F	Males		Females		F	Males		Females		F
Cognitive Mode	N = 1018		N = 1169		(df=1;2185)	N = 374		N = 419		(df=1;791)	N = 317		N = 361		(df=1;676)	N = 333		N = 355		(df=1;686)
All Items	$\bar{x}$	SD	$\bar{x}$	SD		$\bar{x}$	SD	$\bar{x}$	SD		$\bar{x}$	SD	$\bar{x}$	SD		$\bar{x}$	SD	$\bar{x}$	SD	
Recall (R)	72.7	9.0	71.8	11.5	NS	72.6	8.8	72.3	10.1	NS	72.3	8.6	72.3	10.8	NS	73.2	9.6	70.8	13.4	6.5**
Principles (P)	72.2	6.5	72.2	6.9	NS	73.1	6.5	73.6	6.5	NS	71.9	6.5	71.8	6.6	NS	71.6	6.5	70.8	7.2	NS
Questioning (Q)	78.7	10.1	79.9	12.9	5.4**	78.8	9.8	78.8	11.5	NS	78.9	9.3	79.6	12.5	NS	78.3	11.2	81.5	14.2	10.2*
Application (A)	74.0	6.4	74.1	6.5	NS	73.3	6.4	73.5	6.5	NS	74.3	6.4	74.1	6.5	NS	74/5	6.4	74.8	6.6	NS
Biology Items																				
Recall (R)	42.2	6.4	42.1	7.6	11.7*	42.1	6.3	41.1	6.9	4.8**	41.9	6.5	41.2	7.6	NS	42.4	6.5	40.9	8.5	6.7*
Principles (P)	43.8	5.0	44.0	5.0	NS	44.1	5.1	44.8	4.9	3.8**	43.8	5.0	43.8	4.9	NS	43.4	4.8	43.3	5.2	NS
Questioning (Q)	47.2	6.8	47.4	8.5	NS	47.2	6.7	47.1	7.7	NS	47.6	6.4	47.4	8.4	NS	46.8	7.4	47.9	9.5	NS
Application (A)	45.3	4.8	46.0	4.7	13.6*	45.1	4.8	46.0	4.9	6.5*	45.2	4.8	45.9	4.6	3.8**	45.5	5.0	46.2	4.7	3.4**
Physical Science Items																				
Recall (R)	30.5	4.6	30.8	5.5	NS	30.4	4.7	31.2	4.9	4.7**	30.4	4.4	31.0	5.0	NS	30.6	4.8	30.0	6.4	NS
Principles (P)	28.5	4.0	28.2	3.9	NS	29.0	4.0	28.8	3.9	NS	28.2	4.0	28.0	3.6	NS	28.0	3.8	27.6	3.9	NS
Questioning (Q)	31.5	4.9	32.5	5.6	16.2*	31.7	4.7	31.8	5.2	NS	31.3	4.7	32.2	5.6	4.7**	31.6	5.2	33.4	5.8	19.3*
Application (A)	28.8	4.2	28.1	4.0	14.7*	28.2	4.3	27.6	3.7	5.4**	29.1	4.1	28.2	4.2	7.4*	29.0	4.0	28.5	4.0	NS

(**p = .05, *p = 0.01)

Table 6. INTERCORRELATIONS OF SCORES IN COGNITIVE PREFERENCE AREAS FOR TOTAL TEST (ALL STUDENTS) - SCPI*

	R	P	Q
Recall (R)			
Fundamental Principles (P)	.05		
Critical Questioning (Q)	-.72	-.48	
Application (A)	-.43	-.15	-.18

* It should be realized that, in interpreting these correlation coefficients, the ipsative nature of the cognitive preference test, would, per se, result in low negative correlations between the score in one area and those in the remaining areas (for a random score distribution over all areas r-values of -0.33 would be expected).

TABLE 7

VARIMAX ANALYSIS OF COGNITIVE PREFERENCE SCORES (SCPI).

Cognitive Preference Area	Rotated Factor Loadings		
Total Test	Factor 1	Factor 2	Factor 3
Recall (R)	.90	-.05	.27
Principles (P)	.07	.78	.06
Questioning (Q)	-.81	-.49	-.28
Application (A)	-.01	-.04	.76
Percentage of Variance	45.2	28.4	23.8
Biology Items			
Recall (R)	.91	-.20	-.27
Principles (P)	.01	.81	-.09
Questioning (Q)	-.85	-.42	-.31
Application (A)	-.03	-.08	.77
Percentage of Variance	50.3	26.8	23.0
Physical Science Items			
Recall (R)	.74	-.46	-.41
Principles (P)	-.36	.21	.78
Questioning (Q)	-.85	-.50	.07
Application (A)	-.20	.82	-.38
Percentage of Variance	38.1	32.1	27.3

Table 8. Summary of Penang Results - Science Cognitive Preference Inventory

	FORMS (3-5)	ACHIEVEMENT (Superior, High Average, Average)	SEX (Male, Female)	RACE (Chinese, Malay, Indians)
I. ORDER (All Items)	PRINCIPLES ≥ RECALL > APPLICATION ≫ QUESTIONING (Most preferred) (Least preferred)			
II. ANALYSIS OF VARIANCE	1. Significant increase in preference for Principles and Questioning from Forms 3 to 5. 2. Significant decrease in preference for Application from Forms 3 to 5.	Superior group generally shows significantly different: 1. Lesser preference for Recall and Application. 2. Greater preference for Questioning. The largest differences occur in Form 5.	1. In Form 5, significant differences in favor of: (a) Recall - preferred more by girls. (b) Questioning - preferred more by boys. 2. By Form 5 level girls have more firmly established cognitive style likes and dislikes.	No significant differences, no interactions.

Table 9

MEANS SCORES AND F-VALUES FOR ACTIVITY PREFERENCES IN DIFFERENT FORMS (APIS)

Activity Area All Items	ALL FORMS N = 1473		FORM 3 (a) N = 789		FORM 4 (b) N = 685		FORM 5 (c) N = 690		a:b (df=1;1473)	a:c (df=1;1366)	b:c (df=1;1374)
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD			
Laboratory Work (L)	34.1	4.6	33.9	4.7	34.1	4.5	34.4	4.4	NS	NS	NS
Discussion (D)	40.3	5.6	40.3	5.7	40.4	5.5	39.8	5.7	NS	NS	NS
Field Work (F)	33.3	5.2	33.3	5.2	33.5	5.2	33.2	5.2	NS	NS	NS
Reading (R)	34.7	7.2	35.2	6.9	34.8	7.0	34.0	7.6	NS	8.8*	NS
Project Work (P)	34.7	5.7	34.8	5.4	34.7	5.6	34.6	6.0	NS	NS	NS
Biology Items											
Laboratory Work (L)	18.7	3.0	18.6	3.1	18.7	3.0	18.8	2.9	NS	NS	NS
Discussion (D)	21.1	3.3	21.2	3.4	21.2	3.3	20.9	3.4	NS	NS	NS
Field Work (F)	20.2	3.6	20.2	3.6	20.4	3.6	20.1	3.6	NS	NS	NS
Reading (R)	14.8	3.3	15.0	3.2	14.9	3.3	14.6	3.4	NS	4.1**	NS
Project Work (P)	14.8	2.8	15.0	2.7	14.8	2.8	14.6	3.0	NS	4.3**	NS
Physical Science Items											
Laboratory Work (L)	15.4	2.5	15.3	4.5	15.4	2.6	15.4	2.4	NS	NS	NS
Discussion (D)	19.1	2.9	19.1	3.0	19.2	2.9	18.9	3.0	NS	NS	NS
Field Work (F)	13.1	2.8	13.1	2.8	13.2	2.9	13.1	2.8	NS	NS	NS
Reading (R)	19.9	4.5	20.2	4.3	19.9	4.5	19.4	4.7	NS	10.8*	NS
Project Work (P)	19.9	3.6	19.9	3.5	19.9	3.5	19.8	3.8	NS	NS	NS

Only statistically significant F-values reported (**P=0.05, *P=0.01)

TABLE 11

MEAN, STANDARD DEVIATION AND F VALUES FOR ACTIVITY AREAS FOR ACHIEVEMENT (APIS)

Activity Area	ALL ITEMS Achievement Superior		High Average		Average		F Value	BIOLOGY ITEMS Achievement Superior		High Average		Average		F Value	PHYSICAL SCIENCE ITEMS Achievement Superior		High Average		Average		F Value
ALL FORMS	1055		342		767		(df=2; 2161)	1055		342		767		(df=2; 2161)	1055		342		767		(df=2; 2161)
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	
Laboratory Work	33.7	4.6	33.7	4.3	34.7	4.5	13.1*	18.5	2.9	18.4	2.9	19.1	3.1	8.7*	15.2	2.5	15.2	2.5	15.7	2.5	9.7*
Discussion	40.3	5.6	40.2	5.4	39.9	5.6	NS	21.1	3.2	21.1	3.3	20.9	3.4	NS	19.1	3.0	19.2	2.9	19.1	2.9	NS
Field Work	32.8	5.5	33.3	4.8	34.1	4.8	14.9*	19.9	3.6	20.3	3.3	20.7	3.5	12.7*	12.9	2.9	13.0	2.8	13.4	2.8	7.3*
Reading	35.0	7.5	34.4	6.6	34.3	6.9	NS	15.0	3.4	14.7	3.1	14.6	3.3	NS	20.0	4.7	19.7	4.2	19.7	4.3	NS
Project Work	34.6	5.7	34.0	5.7	35.1	5.2	4.1**	14.7	2.8	14.6	2.9	15.0	2.7	NS	19.9	3.7	19.4	3.7	20.1	3.3	4.3**
FORM 3	374		148		267		(df=2; 786)	374		148		267		(df=2; 786)	374		148		267		(df=2; 786)
Laboratory Work	33.6	4.6	33.3	4.7	35.5	4.7	4.6**	18.4	3.1	18.3	3.1	19.0	3.2	NS	15.2	2.4	15.0	2.5	15.6	2.5	NS
Discussion	39.8	5.5	40.4	5.7	41.0	5.8	4.1**	20.9	3.3	21.3	3.5	21.5	3.5	NS	18.8	2.9	19.0	2.9	19.6	3.0	5.4**
Field Work	32.3	5.4	34.1	4.8	34.2	4.8	12.5*	19.8	3.7	20.7	3.3	20.6	3.5	6.0*	12.6	2.9	13.4	2.8	13.6	2.6	11.7*
Reading	36.0	6.6	35.4	6.6	33.8	7.3	8.7*	15.5	3.1	14.7	3.0	14.4	3.4	9.3*	20.6	4.2	20.	4.2	19.4	4.5	7.2*
Project Work	34.7	5.5	34.6	5.7	35.0	5.1	NS	15.0	2.6	14.9	3.0	15.0	2.5	NS	19.8	3.6	19.8	3.5	20.0	3.4	NS
FORM 4	354		103		225		(df=2; 682)	354		103		225		(df=2; 682)	354		103		225		(df=2; 682)
Laboratory Work	33.5	4.6	34.2	4.2	35.1	4.3	9.1*	18.4	3.0	18.7	2.8	19.4	2.9	7.8*	15.1	2.5	15.5	2.7	15.8	2.5	4.5**
Discussion	41.0	5.7	39.5	5.0	39.7	5.3	5.6**	21.6	3.3	20.4	3.2	20.9	3.1	6.7*	19.4	3.0	19.1	2.9	18.8	2.8	NS
Field Work	33.3	5.3	33.6	4.9	34.0	5.0	NS	20.2	3.7	20.4	3.3	20.7	3.4	NS	13.4	2.8	13.2	2.8	13.3	2.9	NS
Reading	35.0	7.6	33.7	7.0	35.0	6.4	NS	15.0	3.4	14.8	3.3	14.9	3.1	NS	20.0	4.7	18.9	4.4	20.2	4.0	NS
Project Work	34.7	6.0	34.8	5.3	34.7	4.9	NS	14.8	3.0	15.0	2.6	14.7	2.6	NS	20.0	3.7	19.8	3.7	20.0	3.2	NNS
FORM 5	324		91		275		(df=2; 687)	324		91		275		(df=2; 687)	324		91		275		(df=2; 687)
Laboratory Work	34.1	4.5	33.6	3.8	34.6	4.5	NS	18.9	2.8	18.3	2.7	18.9	3.0	NS	15.1	2.5	15.4	2.2	15.7	2.4	3.9**
Discussion	40.2	5.5	40.9	5.4	38.9	5.7	6.2**	21.2	3.2	21.4	3.0	20.3	3.4	7.0*	19.0	3.0	19.5	3.0	17.6	2.9	3.9**
Field Work	32.8	5.3	31.6	4.7	34.2	5.1	10.4*	19.7	3.6	19.4	3.1	20.9	3.5	10.6*	13.1	2.9	12.2	2.6	13.3	2.7	5.9**
Reading	34.9	8.3	33.5	6.0	34.3	7.0	NS	14.5	3.6	14.6	2.9	14.8	3.3	NS	19.5	5.2	18.9	3.7	19.5	4.3	NS
Project Work	34.3	6.1	32.1	6.4	35.4	5.8	10.3*	14.5	2.9	13.8	3.0	15.1	3.0	8.1*	19.9	3.8	18.3	4.1	20.3	3.5	4.3**

ONLY SIGNIFICANT F VALUES REPORTED ** p = .05, * p = .01 LEVEL

TABLE 12

MEAN SCORES AND F VALUES OF ACTIVITY PREFERENCES OF MALES AND FEMALES (APIS)

Activity Area	ALL FORMS					FORM 3					FORM 4					FORM 5				
	Males		Females		F	Males		Females		F	Males		Females		F	Males		Females		F
	N = 1025		N = 1139		(df=1;2163)	N = 369		N = 420		(df=1;789)	N = 322		N = 363		(df=1;683)	N = 333		N = 355		(df=1;687)
All Items	$\bar{x}$	SD	$\bar{x}$	SD		$\bar{x}$	SD	$\bar{x}$	SD		$\bar{x}$	SD	$\bar{x}$	SD		$\bar{x}$	SD	$\bar{x}$	SD	
Laboratory Work (L)	34.4	4.5	33.8	4.6	9.0*	33.8	4.6	33.9	4.7	NS	34.7	4.8	33.7	4.5	8.4*	34.7	4.2	33.7	4.5	8.0*
Discussion (D)	40.0	5.6	40.4	5.6	NS	40.0	5.7	40.1	5.7	NS	40.8	5.5	40.0	5.4	NS	38.9	5.5	40.6	5.6	14.9*
Field Work (F)	33.8	4.8	33.0	5.5	11.2*	33.6	4.9	32.9	5.3	3.8**	33.8	4.8	33.3	5.6	NS	33.7	4.8	32.7	5.6	6.6**
Reading (R)	35.3	6.3	34.1	7.8	13.7*	36.1	5.9	34.3	7.6	12.7*	34.7	6.5	34.9	7.6	NS	35.0	6.5	33.2	8.3	9.5*
Project Work (P)	34.7	5.1	34.7	6.0	NS	34.3	4.7	35.2	5.8	4.7**	34.4	5.3	35.1	5.8	NS	35.3	5.4	33.7	6.5	11.6*
Biology Items																				
Laboratory Work (L)	18.9	3.0	18.5	3.0	8.8*	18.6	3.1	18.6	3.1	NS	19.1	2.9	18.4	3.0	8.6*	19.2	2.9	18.6	3.0	7.3**
Discussion (D)	20.9	3.3	21.2	3.3	3.9**	21.0	3.4	21.4	3.4	NS	21.4	3.3	21.0	3.3	NS	20.5	3.3	21.3	3.2	11.2*
Field Work (F)	20.5	3.4	20.1	3.7	6.6**	20.5	3.4	20.0	3.7	3.9**	20.4	3.4	20.4	3.7	NS	20.5	3.4	19.8	3.6	6.1**
Reading (R)	15.1	3.0	14.6	3.5	10.7*	15.4	2.8	14.6	3.4	13.1*	14.8	3.1	15.0	3.4	NS	15.0	3.1	14.3	3.6	7.4**
Project Work (P)	14.8	2.6	14.8	2.9	NS	14.8	2.4	15.1	2.9	NS	14.6	2.7	15.0	2.8	NS	15.4	2.8	14.3	3.1	12.5*
Physical Science Items																				
Laboratory Work (L)	15.5	2.5	15.3	2.5	NS	15.3	2.5	15.3	2.4	NS	15.6	2.6	15.2	2.5	NS	15.6	2.4	15.2	2.4	NS
Discussion (D)	19.0	3.0	19.2	3.0	NS	19.1	3.4	19.2	3.4	NS	19.4	2.9	19.0	2.9	NS	18.5	2.9	19.3	2.9	12.0*
Field Work (F)	13.3	2.6	12.9	2.9	8.9*	13.2	2.7	13.0	3.0	NS	13.5	2.7	12.9	3.0	5.8**	13.2	2.5	12.9	3.0	NS
Reading (R)	20.2	4.0	19.5	4.8	12.5*	20.7	3.9	19.8	4.7	9.1*	19.9	4.1	19.9	4.8	NS	20.0	4.1	18.9	5.1	9.2*
Project Work (P)	19.9	3.4	19.9	3.8	NS	19.6	3.3	20.1	3.7	NS	19.8	3.3	20.1	3.7	NS	20.2	3.5	19.4	4.0	7.2**

(**p = 0.5 level, *p = 0.01 level)

TABLE 13

MEAN, STANDARD DEVIATION AND F VALUES FOR ACTIVITY AREAS FOR RACE (APIS)

Activity Area	ALL ITEMS RACE						F Value (df=2, 2161)	BIOLOGY ITEMS RACE						F Value (df=2; 2161)	PHYSICAL SCIENCE ITEMS RACE						F Value (df=2; 2161)
	CHINESE		MALAYS		INDIANS			CHINESE		MALAYS		INDIANS			CHINESE		MALAYS		INDIANS		
	N=149		N=507		N=166			N=149		N=507		N=166			N=1491		N=507		N=166		
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	
Laboratory Work	33.8	4.5	34.5	4.7	35.0	4.5	7.8	18.6	3.0	18.9	3.1	19.5	3.0	8.2*	15.3	2.5	15.6	2.6	15.6	2.4	NS
Discussion	40.5	5.5	39.2	5.4	39.6	6.2	11.1*	21.3	3.3	20.6	3.3	20.7	3.5	10.2*	19.2	3.0	18.6	2.9	18.9	3.2	7.5*
Field Work	33.1	5.2	34.1	5.0	33.6	5.5	7.8*	20.1	3.5	20.6	3.5	20.6	3.8	5.9**	13.0	2.9	13.5	2.8	13.0	2.9	5.5**
Reading	34.9	7.3	34.2	7.1	33.6	7.4	4.5**	15.0	3.3	14.6	3.3	14.2	3.2	5.6**	20.0	4.5	19.6	4.4	19.4	4.7	NS
Project Work	34.2	5.7	35.6	5.2	35.6	5.5	12.8	13.2	2.6	13.8	2.5	13.6	2.3	11.7*	19.6	3.6	20.4	3.6	20.5	3.9	9.3*
FORM 3	N=547		N=173		N=69		(df=2; 786)	N=547		N=173		N=69		(df=2; 786)	N=547		N=173		N=69		(df=2; 786)
Laboratory Work	33.6	4.6	34.1	4.8	35.1	4.7	NS	18.4	3.1	18.7	3.1	19.4	3.1	NS	15.2	2.5	15.4	2.5	15.7	2.4	NS
Discussion	40.6	5.3	39.7	5.6	39.9	6.5	NS	21.4	3.4	22.8	3.5	23.0	3.6	3.8**	19.2	2.9	19.0	3.0	19.1	3.4	NS
Field Work	33.1	5.1	33.9	5.2	33.3	5.1	NS	20.1	3.5	20.5	3.5	20.5	3.6	NS	13.0	2.8	13.4	2.8	12.8	2.9	NS
Reading	35.3	6.9	34.9	7.0	34.4	7.2	NS	15.1	3.2	14.8	3.2	14.4	3.2	NS	20.3	4.3	20.1	4.5	20.0	4.6	NS
Project Work	34.6	5.4	35.1	5.3	35.3	5.1	NS	14.8	2.7	15.3	2.6	15.2	2.3	NS	19.8	3.6	19.8	3.5	20.2	3.7	NS
FORM 4	N=541		N=187		N=47		(df=2; 682)	N=451		N=187		N=47		(df=2; 682)	N=451		N=187		N=47		(df=2; 682)
Laboratory Work	33.9	4.4	34.5	4.9	34.7	4.4	NS	18.6	2.8	18.9	3.3	19.6	2.7	NS	15.3	2.5	15.6	2.7	15.1	2.6	NS
Discussion	40.9	5.4	38.9	5.4	40.7	5.9	9.1*	21.5	3.2	20.4	3.2	21.3	3.5	6.9*	19.4	2.9	18.5	2.8	19.4	3.1	7.3*
Field Work	33.5	5.2	34.0	5.3	32.4	5.5	NS	20.4	3.4	20.6	3.8	19.7	3.8	NS	13.1	2.9	2.9	2.9	12.8	2.9	NS
Reading	35.1	7.1	34.2	7.2	34.0	7.4	NS	15.0	3.3	14.7	3.4	14.4	3.0	NS	20.1	4.5	4.4	4.4	19.6	4.9	NS
Project Work	34.1	5.5	36.1	5.4	34.8	5.8	8.8*	14.5	2.8	15.5	2.7	15.4	2.6	7.4*	19.6	3.5	3.5	3.5	20.1	3.8	6.4*
FORM 5	N=493		N=147		N=50		(df=2; 687)	N=493		N=147		N=50		(df=2; 687)	N=493		N=147		N=50		(df=2; 687)
Laboratory Work	33.9	4.3	34.8	4.1	35.2	4.5	3.9**	18.7	2.9	19.1	2.8	19.5	3.2	NS	15.2	2.4	15.7	2.4	15.8	2.2	NS
Discussion	40.2	5.6	39.1	5.3	38.3	5.9	3.9**	21.0	3.3	20.7	3.2	20.1	3.4	NS	19.1	3.0	18.5	2.8	18.2	3.1	4.6**
Field Work	32.6	5.4	34.1	4.3	35.0	5.8	9.6*	19.8	3.6	20.9	3.1	21.6	3.9	10.5*	12.9	2.9	13.5	2.3	13.4	3.0	NS
Reading	34.5	7.6	33.3	7.2	32.1	7.5	NS	14.8	3.4	14.2	3.1	14.8	3.5	NS	19.6	4.7	19.1	4.6	18.2	4.6	NS
Project Work	33.9	6.1	35.4	6.1	36.7	5.7	7.3*	14.5	3.0	15.0	2.9	15.3	2.9	NS	19.5	3.7	20.4	3.8	21.5	3.5	8.8*

ONLY SIGNIFICANT F VALUES REPORTED ** p = .05, * p = .01 LEVEL

Table 14

INTERCORRELATIONS OF SCORES IN ACTIVITY PREFERENCE AREAS (TOTAL SAMPLE) (APIS)*

Activity Area	L	D	F	R
Laboratory Work (L)				
Discussion (D)	-.36			
Field Work (F)	-.03	-.40		
Reading (R)	-.48	-.05	-.31	
Project Work (P)	+.06	-.50	+.04	-.38

* It should be noted that, in interpreting these correlation coefficients, they are ipsative in nature and would, per se, result in low negative correlations between the score in one area and those in the remaining areas (for a random score distribution over all areas γ-values of -0.25 would be expected).

TABLE 15

VARIMAX ANALYSIS OF ACTIVITY PREFERENCE SCORES (APIS).

Activity Preference Area	Rotated Factor Loadings		
Total Test	Factor 1	Factor 2	Factor 3
Laboratory Work (L)	.57	.25	.02
Discussion (D)	-.06	-.90	-.15
Field Work (F)	.13	.12	.67
Reading (R)	-.91	.09	-.34
Project Work (P)	.47	.48	-.08
Percentage of Variance	44.2	21.18	18.3
Biology Items			
Laboratory Work (L)	.47	.25	-.02
Discussion (D)	.01	-.92	-.31
Field Work (F)	.07	.10	.85
Reading (R)	-.97	.02	-.15
Project Work (P)	.31	.48	-.10
Percentage of Variance	38.3	24.2	20.1
Physical Science Items			
Laboratory Work (L)	.14	.17	.73
Discussion (D)	.17	-.77	-.23
Field Work (F)	.40	.01	.01
Reading (R)	-.92	-.01	-.34
Project Work (P)	.49	.66	.04
Percentage of Variance	40.0	25.5	17.8

Table 16. Summary of Penang Results -- Activity Preferences in Science (APIS)

	FORMS (3-5)	ACHIEVEMENT (Superior, High Average, Average)	SEX (Male, Female)	RACE (Chinese, Malays, Indians)
I. ORDER (All Items)	F I E L D > L A B O R A T O R Y > P R O J E C T S ≫ R E A D I N G ≫ D I S C U S S I O N (Most preferred----------Least preferred)			
II. ANALYSIS OF VARIANCE	1. Significant increase in preference for Reading from Forms 3-5 for All Items and both subject areas. 2. Significant increase in preference for Projects in biology from Forms 3-5. 3. Decrease in preference for Laboratory from Forms 3-5.	1. Superior and High Average students show significantly greater preference for Laboratory and Field than Average students. 2. Superior and High Average students (mainly in Form 5) show a significantly greater preference for Projects than average students. 3. In Forms 4 and 5, Average students have a significantly greater preference for Discussion than the other students. 4. Except for Average Form 3 pupils, there are no significant differences between groups for Reading.	1. Reading preferred more by girls than boys; significantly different for All Items, All Forms, Subjects, and Forms 3 and 5. 2. Laboratory and Field preferred significantly more by girls than boys (All Forms). 3. More significant differences between sexes occur in Form 5 and fewer in Form 4.	1. Chinese generally have greater preference for Laboratory, Field, and Projects than other racial groups. 2. Malays (and Indians in Form 5) have a greater preference for Discussion than other groups. 3. Only minor differences between Malays and Indians.

TABLE 17

MEAN SCORES AND F VALUES IN ACTIVITY CATEGORIES IN DIFFERENT FORMS

CATEGORY	ALL STUDENTS N = 2172		FORM 3 (a) N = 785		FORM 4 (b) N = 692		FORM 5 (c) N = 695		F a:b (df= 1;1475)	F a:c (df= 1;1478)	F b:c (df= 1;385)
Category	$\bar{x}$	SD	$\bar{x}$1	SD	$\bar{x}$	SD	$\bar{x}$	SD			
Laboratory Activities	58.8	10.3	57.9	9.2	58.5	11.6	60.1	10.0	NS	20.0*	7.6
Evaluation	27.9	4.6	28.4	4.6	27.5	4.3	27.7	4.7	14.2*	7.9*	NS
Class Activities	27.3	4.8	28.4	5.0	26.6	4.7	26.6	4.6	54.8*	54.4*	NS
Nature of Science	19.2	4.0	18.8	3.8	18.8	4.1	20.0	4.2	NS	31.1*	28.3*
Teacher Role	36.3	6.9	35.5	6.9	35.9	6.8	37.5	6.9	NS	31.1*	19.5*

Only significant F values are reported * p = 0.01

TABLE 18

MEANS, STANDARDS DEVIATIONS AND F VALUES FOR ACTIVITY CATEGORIES IN DIFFERENT FORMS

CATEGORY	ACHIEVEMENT									F Value
	Superior			High Average			Average			
ALL FORMS	N= 1069			N= 332			N= 771			(df=2;2169)
	$\bar{x}$	SD	I	$\bar{x}$	SD	I	$\bar{x}$	SD	I	
Laboratory Activities	57.9	9.5	3.05	58.2	9.8	3.06	63.1	12.6	3.32	34.9*
Evaluation	28.3	4.5	3.14	28.2	4.5	3.14	27.3	4.6	3.03	NS
Class Activities	27.6	4.9	3.07	27.3	4.8	3.03	27.0	4.8	3.00	NS
Scientific Inquiry	19.5	4.0	3.25	19.6	3.8	3.26	18.8	4.2	3.13	NS
Teacher Role	36.1	6.6	2.58	36.1	7.3	2.58	37.4	6.8	2.67	5.2**
FORM 3	N= 369			N= 148			N= 268			(df=2;782)
Laboratory Activities	58.6	9.5	3.08	56.9	7.8	3.00	60.9	8.6	3.20	10.2*
Evaluation	29.0	4.3	3.22	29.0	4.5	3.22	27.4	4.8	3.04	10.1*
Class Activities	28.7	4.9	3.18	29.0	5.1	3.22	27.6	4.8	3.07	5.9**
Scientific Inquiry	19.3	3.8	3.21	19.2	3.6	3.20	17.9	3.7	2.98	11.6*
Teacher Role	35.8	6.8	2.56	36.4	6.8	2.60	34.7	7.0	2.48	NS
FORM 4	N= 360			N= 104			N= 228			(df=2;689)
Laboratory Activities	56.5	9.4	2.97	57.6	9.5	3.03	67.6	10.9	3.56	42.8*
Evaluation	27.7	4.5	3.07	27.9	4.2	3.10	27.1	4.2	3.01	NS
Class Activities	26.5	4.5	2.94	26.8	4.2	2.97	26.6	5.0	2.95	NS
Scientific Inquiry	20.5	3.9	3.41	18.6	4.0	3.10	18.3	4.1	3.05	12.8*
Teacher Role	35.6	6.4	2.54	34.8	6.8	2.49	39.3	7.3	2.80	16.0*
FORM 5	N= 340			N= 80			N= 278			(df=2;695)
Laboratory Activities	58.7	9.4	3.08	61.1	10.3	3.21	61.6	10.3	3.24	7.1*
Evaluation	28.3	4.7	3.14	27.2	4.5	3.03	26.9	4.8	2.98	5.4**
Class Activities	26.6	4.6	2.96	26.0	4.9	2.88	26.7	4.5	2.97	NS
Scientific Inquiry	19.9	4.2	3.32	19.8	3.4	3.30	20.3	4.3	3.38	NS
Teacher Role	.	6.6	2.64	36.7	5.4	2.62	38.4	7.6	2.74	3.9**

ONLY SIGNIFICAMT F VALUES ARE REPORTED ** p = .05, * p = .01 LEVEL.

TABLE 19

MEANS, STANDARD DEVIATIONS AND F VALUES FOR ACTIVITY CATEGORIES FOR MALES AND FEMALES (SAC)

Category	SEX Males			Females			F Value
ALL FORMS	N=1010			N=1172			
	$\bar{x}$	SD	I	$\bar{x}$	SD	I	(df=1;2172)
Laboratory Activities	56.8	9.5	2.99	60.5	10.6	3.18	72.3*
Evaluation	26.9	4.6	2.98	28.7	4.4	3.19	85.3*
Class Activities	26.7	4.8	2.97	27.7	4.8	3.08	23.9*
Scientific Inquiry	18.9	4.0	3.15	19.4	4.0	3.23	8.5*
Teacher Role	35.4	6.7	2.52	37.4	7.0	2.67	30.9*
FORM 3	N= 364			N=421			(df=1;783)
Laboratory Activities	56.4	9.3	3.14	59.2	9.1	3.12	17.5*
Evaluation	27.5	4.5	3.05	29.2	4.5	3.24	30.7*
Class Activities	27.5	5.1	3.05	29.2	4.7	3.24	24.5**
Scientific Inquiry	18.5	3.7	3.08	19.0	3.8	3.17	NS
Teacher Role	34.5	6.8	2.46	36.5	6.8	2.60	16.7*
FORM 4	N= 326			N=366			(df=1;690)
Laboratory Activities	55.0	8.9	2.89	61.5	12.7	3.24	61.5*
Evaluation	26.7	4.3	2.97	28.2	4.2	3.13	21.5*
Class Activities	26.1	4.6	2.90	27.0	4.6	2.98	6.0**
Scientific Inquiry	18.4	4.0	3.07	19.1	4.1	3.18	4.8*
Teacher Role	34.8	6.7	2.49	36.9	6.8	2.64	16.8*
FORM 5	N= 320			N=375			(df=1;693)
Laboratory Activities	59.1	9.6	3.11	61.0	10.2	3.21	6.0**
Evaluation	26.2	4.9	2.91	28.7	4.4	3.19	33.7*
Class Activities	26.4	4.6	2.93	26.7	4.7	2.97	NS
Scientific Inquiry	19.8	4.1	3.30	20.1	4.2	3.35	NS
Teacher Role	37.1	6.5	2.65	37.8	7.2	2.70	NS

ONLY SIGNIFICANT F VALUES ARE REPORTED ** p = .05, * p = .01

TABLE 20

MEANS, STANDARD DEVIATION FOR ACTIVITY CATEGORIES IN DIFFERENT FORMS (SAC)

CATEGORY	CHINESE N=1464			MALAYS N=542			INDIANS N=166			F VALUES
ALL FORMS	$\bar{x}$	SD	I	$\bar{x}$	SD	I	$\bar{x}$	SD	I	(df=2;2169)
Laboratory Activities	59.4	10.6	3.13	57.9	9.7	3.05	56.9	9.4	3.00	6.9*
Evaluation	28.3	4.5	3.14	27.2	4.5	3.01	27.1	4.6	3.02	12.7*
Class Activities	27.6	5.0	3.07	26.5	4.5	2.94	26.6	4.7	2.94	10.5*
Nature of Science	19.3	4.2	3.21	18.9	3.7	3.15	19.4	3.8	3.21	NS
Teacher Role	36.7	6.9	2.62	35.7	6.7	2.55	35.0	7.4	2.50	7.2*
FORM 3		N=542			N=173			N=70		(df=2;782)
Laboratory Activities	58.4	9.6	3.07	56.5	8.5	2.97	57.3	8.7	3.02	NS
Evaluation	28.8	4.5	3.20	27.5	4.7	3.07	27.6	4.7	3.07	6.6*
Class Activities	28.8	5.1	3.20	27.3	4.6	3.03	28.1	4.1	3.12	5.9**
Nature of Science	18.9	3.9	3.15	18.2	4.2	3.03	19.3	3.4	3.21	NS
Teacher Role	35.9	6.9	2.56	34.6	6.4	2.47	34.9	7.4	2.49	NS
FORM 4		N=454			N=190			N=48		(df=2;689)
Laboratory Activities	58.8	11.7	3.09	58.8	11.2	3.09	55.2	10.7	2.93	NS
Evaluation	27.8	4.3	3.09	27.0	4.4	3.01	27.1	4.2	3.02	NS
Class Activities	26.8	4.8	2.98	26.3	4.4	2.92	25.8	4.6	2.87	NS
Nature of Science	18.7	4.1	3.12	19.0	3.9	3.17	18.3	4.0	3.05	NS
Teacher Role	36.0	6.6	2.57	36.0	7.2	2.57	34.5	7.8	2.47	NS
FORM 5		N=468			N=179			N=45		(df=2;689)
Laboratory Activities	61.0	10.3	3.21	58.3	9.1	3.07	58.1	9.2	3.06	5.9**
Evaluation	28.0	4.8	3.11	27.2	4.6	3.02	26.5	4.8	2.95	3.9**
Class Activities	26.9	4.7	2.99	26.0	4.3	2.89	25.3	5.0	2.81	4.3**
Nature of Science	20.2	4.3	3.37	19.3	3.7	3.21	19.6	4.2	3.27	3.2**
Teacher Role	38.2	7.0	2.73	36.4	6.4	2.60	35.6	7.0	2.54	6.3*

ONLY SIGNIFICANT F VALUES ARE REPORTED ** p = .05, * p = .01.

Table 21. Summary of Penang Data - Science Activity Checklist (SAC)

	FORMS (3-5)	ACHIEVEMENT (Superior, High Average, Average)	SEX (Male, Female)	RACE (Chinese, Malays, Indians)
I. ORDER	SCIENTIFIC INQUIRY ACTIVITIES > EVALUATION ACTIVITIES ≥ LABORATORY ACTIVITIES > CLASS ACTIVITIES > TEACHER ROLE ACTIVITIES (Most traditional; least inquiry-oriented)			(Least traditional; most inquiry-oriented)
II. ANALYSIS OF VARIANCE	1. Significant increase in traditional approach to Laboratory, Scientific Inquiry, and Teacher Role (that is, significant decrease in inquiry) from Forms 3 to 5.) 2. Decrease in traditional approach to Evaluation and Class Activities (that is, an increase in inquiry from Forms 3 to 5.)	1. Laboratory seen as significantly more inquiry oriented by superior than by average achievers (All Forms and Forms 3 to 5.) 2. Teacher Role seen as significantly more inquiry oriented by superior than by average achievers (All Forms and Forms 4 and 5). 3. Evaluation seen as significantly more inquiry oriented by average than by superior achievers (Forms 3 and 5). 4. Scientific Inquiry seen as significantly more inquiry oriented by average than by superior students (Form 3).	1. Boys have more inquiry oriented science than girls (significantly so in Forms 3 and 4, and for All Forms in at least four out of the five activity categories). 2. For both sexes, general trend towards: (a) more formal type of instruction in Form 5 and, (b) a more similar classroom environment in Form 5 compared with lower forms.	1. Chinese tend to perceive (significantly so at Form 5) science instruction as more formal and traditional than the other races. 2. Malays and Indians seem to perceive science instruction as more inquiry oriented .